FORUM

Building on the Basics About Soil Carbon

A few facts and figures about soil carbon:

•Plants pull carbon dioxide (CO_2) from the air during photosynthesis. Some of the carbon that becomes green plant material can make its way into the soil through the process of decay from soil microbes.

•There are around 720 million tons of carbon in our planet's terrestrial ecosystem, and around 352 million tons are in the form of organic soil carbon.

•Converting forests and grasslands to cropland and pasture over the last several hundred years has released 11 to 23 million tons of soil carbon into the atmosphere.

•U.S. farmers sequester about 11.2 million tons of CO_2 every year in the form of soil carbon by converting cropland back to grassland, increasing conservation tillage and continuous cropping, and improving organic fertilizer management.

Even better, strategies that increase CO_2 sequestration and protect soil carbon levels generally improve crop production efficiency as well, helping farmers meet production targets and protect air quality. So, depending on who you ask, the agronomic benefits from sequestering carbon in the soil might even trump the benefits of removing CO_2 from the atmosphere.

We've known for years that maintaining plant residues on the soil surface, adopting complex cropping systems that provide continuous ground cover, and applying carbon-rich amendments can add significant amounts of carbon to the soil. Yet we still had a lot of questions about soil carbon dynamics.

So in 2002, scientists from the Agricultural Research Service and outside collaborators established a national network of soil carbon research projects called "GRACEnet" (Greenhouse-Gas Reduction through Agricultural Carbon Enhancement Network). We developed this network to coordinate research projects at multiple ARS locations and determine the effects of management practices on soil carbon sequestration, trace gas emissions, and environmental quality. We also wanted to use this information to develop new management practices that reduce net greenhouse gas emissions and increase soil carbon sequestration.

Since GRACEnet was established, researchers have published more than 250 papers that have helped to fill in the blanks about how land-based agricultural practices affect greenhouse gas emissions and soil carbon dynamics. In 2012, many of GRACEnet's research highlights were published in a book called "Managing Agricultural Greenhouse Gases: Coordinated Agricultural Research through GRACEnet to Address our Changing Climate."

The book was edited by three ARS scientists—Mark Liebig, Alan Franzluebbers, and Ron Follett. Over100 ARS scientists contributed to it, as did collaborators from other government agencies, universities, and private industry.

Much of the content is about soil carbon, including how to measure it, how it is lost, and how it can be protected and replaced.

What have we found so far?

In the eastern United States, adopting no-till crop production can typically sequester around 450 pounds of carbon per acre per year.

In central U.S. agroecosystems, complex crop rotations can increase carbon soil sequestration.

In western U.S. dryland systems, soil carbon accumulates slowly, because the lower biomass yields mean that plants are adding less carbon to the soil. But adopting no-till management in this region increases the accumulation of surface crop residue and organic carbon.

Farmers working on intensely irrigated systems in the western United States could increase soil carbon levels by improving grazing regimes, fertilization practices, and irrigation management.

Rangelands typically have short periods of high carbon inputs to the soil during the growing season, followed by long periods of soil carbon balance or small losses for the rest of the year.

Improved pasture management—including plant composition, stocking rate, and stocking methods—could significantly increase soil carbon sequestration rates.

Overzealous harvesting of biomass feedstock—for instance, removing much or all of the postharvest corn stover from a field—may exacerbate a decline in soil carbon and water quality and accelerate soil erosion. Producers can compensate for these potential soil carbon losses by reducing or eliminating tillage, adding cover crops, and including or expanding the presence of perennial crops.

Changing from row crops to perennial "energy grasses," such as switchgrass, can sequester 440 to 670 pounds of carbon per acre per year.

The story on page 4 of this issue features the results of some long-term ARS studies of soil carbon dynamics in annual and perennial crops. The findings underscore how deeply we need to dig into the soil—and how long we need to track changes in the soil—to fully understand the many factors that promote soil carbon retention and loss.

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